The Rano Kau 2 Pollen Diagram: Palaeoecology Revealed

K. R. Butler and J. R. Flenley
School of People, Environment, and Planning, Massey University, New Zealand

INTRODUCTION

OF THE THREE POTENTIAL SITES ON RAPA NUI for recovering a continuous palaeoecological record (Flenley et al.1991) Rano Kau has so far proved the best. Rano Raraku has a significant hiatus between 800 BP and c. 2000 BP (Mann et al.2008) and Rano Aroi has surface disturbance, as well as being above the altitude of likely early inhabitants. Rano Kau, however, offered a favorable microclimate for tropical crops (van Steenis 1935), a permanent water supply for early inhabitants, and a long continuous pollen record.

Rano Kau core 1, collected in 1977 near the edge of the swamp, yielded a record spanning only just over a millennium. Rano Kau 2, collected in 1977 and near the centre of the caldera, however, has given a continuous record for the last 10 millenia. Initial problems with dating have now been resolved. Furthermore the position near the centre of Rano Kau is likely to give a more generalized record of the palaeoecology. We originally expected this to be an island-wide coverage, as predicted for the centre of large sites by Jacobsen and Bradshaw (1981). The caldera is, however, so deep (c. 200 metres), and the interior slopes so steep (c.30^{o}), that the interior environment is almost windless, and rather isolated from the windy environment of the rest of the island. The result appears to be that each core taken reflects the vegetation on the nearest caldera slopes, with relatively less input than usual from the rest of the island or from long distance transported pollen.

STRATIGRAPHY

The core was taken on a floating mat of living rhizomes of *Scirpus californicus*, the totora reed (called *nga'atu* in Rapanui), which dominates the swamp today. Below that was coarse organic detritus down to 3 metres depth. Next came an 8 metre water gap, down to 11 metres depth. There was then a further 10 metres of medium organic detritus, down to 21 metres depth. This was not the bottom, but was the maximum extent of the core equipment available at that time.

DATING

Initial radiocarbon dating was carried out using bulk sediment dating and, while it gave the impression that the core covered the entire Holocene, there were some inversions. Since bulk sediment samples often have this problem, we dated the core again using carefully selected macrofossils, especially *Scirpus* fruits. The results are shown in Table 1, and show a better chronology, with only one inversion, which is in the top 2 metres of the core.

Table 1. Radiocarbon age determinations for Rano Kao borehole 2.

Depth	Code Number	Date in Calibrated yrs BP (1 sigma)	Material Dated
0.78 – 0.81 m	NZA 27729	435 – 350	Scirpus macrofossils
1.75 – 1.78 m	NZA 27750	676 – 660	Scirpus macrofossils
2.45 – 2.50 m	NZA 27727	518 – 501	Scirpus macrofossils
2.75 – 2.80 m	NZA 27751	505 – 475	Scirpus macrofossils
2.85 – 2.95 m	NUTA 3515	1279 – 789	Bulk sediment
11.35 – 11.45 m	NUTA 3011	1046 – 655	Bulk sediment
12.55 – 12.60 m	NZA 27752	1894 – 1825	Scirpus macrofossils
14.07 – 14.10 m	NZA 27753	1949 – 1887	Scirpus macrofossils
14.85 – 14.95 m	NUTA 3013	1856 – 1288	Bulk sediment
15.95 – 16.00 m	NZA 27754	3860 – 3721	Scirpus macrofossils
17.85 – 17.95 m	NUTA 3516	11,211 – 10,273	Bulk sediment
19.10 – 19.13 m	NZA 27755	9551 – 9532	Scirpus macrofossils
19.80 – 19.83 m	NZA 27732	10,184 – 9917	Scirpus macrofossils
20.50 – 20.63 m	NUTA 3012	10,699 – 9780	Bulk sediment

PALYNOLOGY

The palynological methods and the summary results for this core have been reported previously (Butler and Flenley, 2001). The results are here re-graphed (Figure 1) to make interpretation easier as the new pollen diagram shows the full range of *taxa* identified and additional results that have been obtained since the 2001 report. Since there is no surviving natural vegetation on the island, the method of interpretation is necessarily based on general ecological principles and knowledge from other islands. The diagram has therefore also been zoned using general principles rather than statistical techniques.

The zones are as follows:

<u>Zone RK2-1, 21 m. – 20.3 m., c.10500 to 10000 BP</u>
High percentages (some >80%) of palm pollen, Poaceae almost absent. Charcoal is at background levels.

<u>Zone RK2-2, 20.3 m. – 19 m., c.10000 to 9600 BP</u>
Reduced palm pollen (one <40%) and temporary peaks of shrubby taxa such as Asteraceae (Tubuliflorae), *Coprosma*, *Sophora* (toromiro) and *Triumfetta* (hau-hau). There is also a

multiple peak of Poaceae and a single peak of charcoal. Wetland taxa are common.

Zone RK2-3, 19 m. – 14 m., c.9600 to 1900 BP
High palm percentages (80 – 90%), low shrub percentages, low Poaceae (10 – 20%), low values for ferns, and charcoal at background levels.

Zone RK2-4, 14 m. – 13 m., c. 1900 to 1850 BP
Palm pollen drastically reduced (4 values <20%), Poaceae rises to 70%, there is a charcoal peak, *Sophora* has peak values, ferns also peak.

Zone RK2 -5, 13 m. – 11 m., c.1850 to 1000 BP
Palm pollen recovers, but only once to previous levels, and fluctuates. Poaceae fluctuates between 40% and 90%. Shrub values fluctuate, with peaks for Urticaceae / Moraceae. Charcoal also has frequent peaks, as do ferns and wetland taxa.

Water Gap, 11 m. – 3 m., c.1000 BP or later
At the end of zone RK2-5 there appears to have been a significant rise of the water table in the caldera. At the time of coring this rise amounted to a water depth of 8 metres. This rise in the water table seems to have caused the surface of the swamp, probably the mass held together by the *Scirpus* rhizomes and root structure, to split off from the detritus beneath, and to form the floating mats of today. The exact date of this event is unknown. It could have been a single event or a progressive one.

Zone RK2-6, 3 m. – 2 m., c.1000 to 600 BP
Palm pollen values recover to 80% at times, Poaceae values fall to around 20%. Shrubs are rather low, ferns are consistently high. Charcoal fluctuates with some high values.

Zone RK2-7, 2 m. – 0.5 m., c.600 to 150 BP
Palm pollen values generally decline, as do *Sophora* and *Triumfetta*. Urticaceae/Moraceae rise to high values. Poaceae progressively increases to very high values, as does charcoal. *Polygonum* reaches high values.

Zone RK2-8, 0.5 m – 0.0 m., c.150 BP to present.
Palmae, *Sophora*, and *Triumfetta* disappear completely, but Urticaceae/Moraceae survive. Poaceae and charcoal reach their highest values of all. Wetland taxa, including *Polygonum*, remain abundant, as do ferns.

INTERPRETATION

Zone RK2-1, 21 m. – 20.3 m., c.10500 to 10000 BP
The vegetation appears to have been a dense Palm forest, allowing almost no grasses. A sub-tropical rainforest is suggested. The background charcoal is probably carried long distance from South America and/or Australia (Butler 2008). The climate was most likely warm and wet.

Zone RK2-2, 20.3 m. – 19 m., c.10000 to 9600 BP
The Palm forest declined and was partially replaced by shrubs such as Asteraceae (Tubuliflorae), *Sophora* and *Triumfetta*. The vegetation was more open, allowing grasses and ferns to thrive. A peak of charcoal suggests a fire, most likely a natural fire on the island. This fire was probably volcanic in origin since volcanic ash was recorded in Rano Raraku slightly earlier than these dates (Flenley et al., 1991). This period was probably a natural climatic oscillation as occurred in many places around this time. A similar one a little earlier was recorded from Rano Raraku by Azizi and Flenley (2008). The climate probably became temporarily cooler and drier.

Zone RK2-3, 19 m. – 14 m., c.9600 to 1900 BP
This period represents the post-glacial forest, dominated by palms (*Paschalococos disperta*), but with an understorey which included *Sophora* and *Triumfetta*. This was a moist, dense forest allowing only a minor presence of grasses. It almost certainly contained other species listed by Orliac and Orliac (2005) and was a sub-tropical rain forest, not the 'woodland' described by Mieth and Bork (2010). The term woodland implies an open canopy, as defined by Costin (1954).

The climate was sufficiently moist for this forest to thrive, but sedimentation rate in the swamp was rather low. This could have been the result of absorption of nutrients by the dense forest, allowing few to leach into the swamp and even fewer into the more central parts of the caldera's swamp. Alternatively, it could be that the climate was drier but this seems unlikely given the dominance of the forest.

Zone RK2-4, 14 m. – 13 m., c. 1900 to 1850 BP
This is the first good evidence of disturbance of the forest. There appears to have been fire, and the palm forest was drastically reduced. Regrowth of *Sophora* occurred. Grasses flourished, as did the ferns. Whether this disturbance was caused by climate, vulcanicity, or people is uncertain, and must await further research which is underway. Volcanic activity is possible as Maunga Hiva-hiva volcano was active within the last 2000 years (Gonzalez-Ferran 2004). Climate change is not impossible, although lightning fires are rare on the Pacific Islands today (Doswell 2002). An arrival of people at this time would be in line with the linguistic evidence (Flenley and Bahn, 2003).

Zone RK2 -5, 13 m. – 11 m., c.1850 to 1000 BP
The forest partially recovered during this phase, at least within the crater. The walls of the crater were perhaps partly used for cultivation of paper mulberry (pollen of Urticaceae/ Moraceae) for making tapa-cloth.

At the end of this zone, there appears to have been a dramatic increase in precipitation. This not only led to a rise of the water table, but probably flooded the marginal gardens around the edge of the swamp, as the water level progressively rose by several metres. The extra precipitation proba-

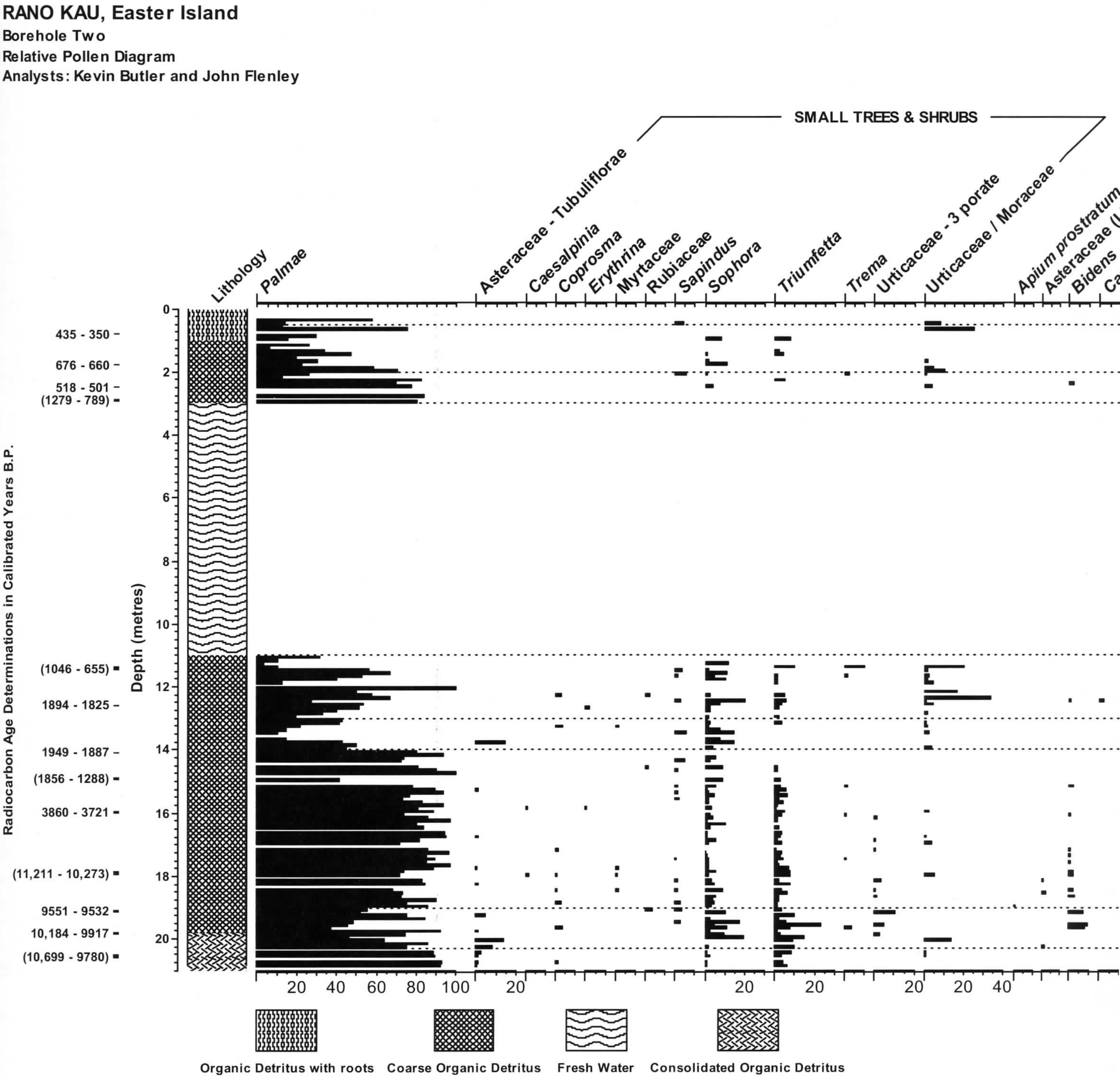
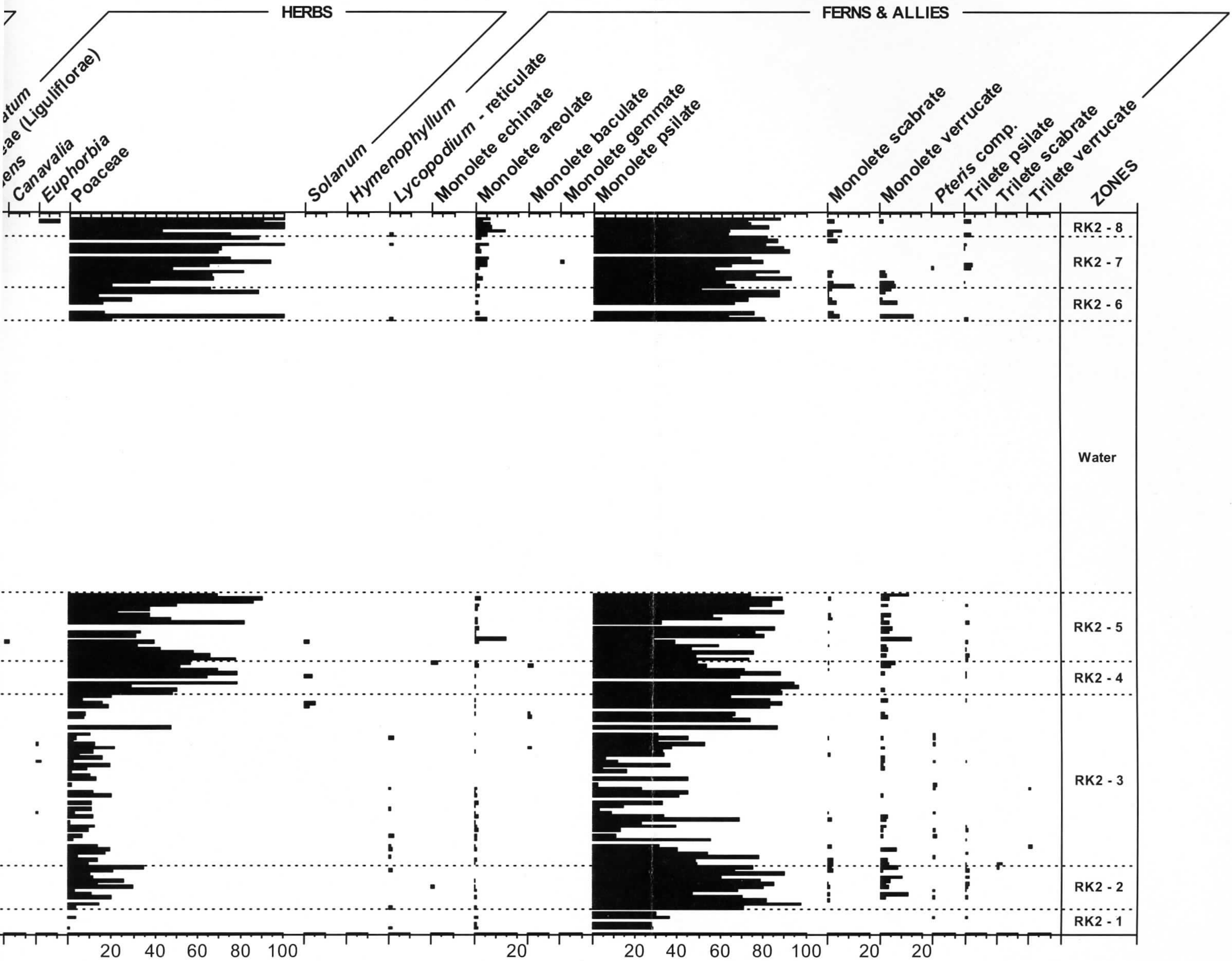


Figure 1. The complete pollen diagram from Rano Kau borehole 2. The coring details are given in Flenley et al. (1991).


HERBS
FERNS & ALLIES
Canavalia
Euphorbia
Poaceae
Solanum
Hymenophyllum
Lycopodium - reticulate
Monolete echinate
Monolete areolate
Monolete baculate
Monolete gemmate
Monolete psilate
Monolete scabrate
Monolete verrucate
Pteris comp.
Trilete psilate
Trilete scabrate
Trilete verrucate
ZONES
RK2 - 8
RK2 - 7
RK2 - 6
Water
RK2 - 5
RK2 - 4
RK2 - 3
RK2 - 2
RK2 - 1
20 40 60 80 100
20
20 40 60 80 100
20
20

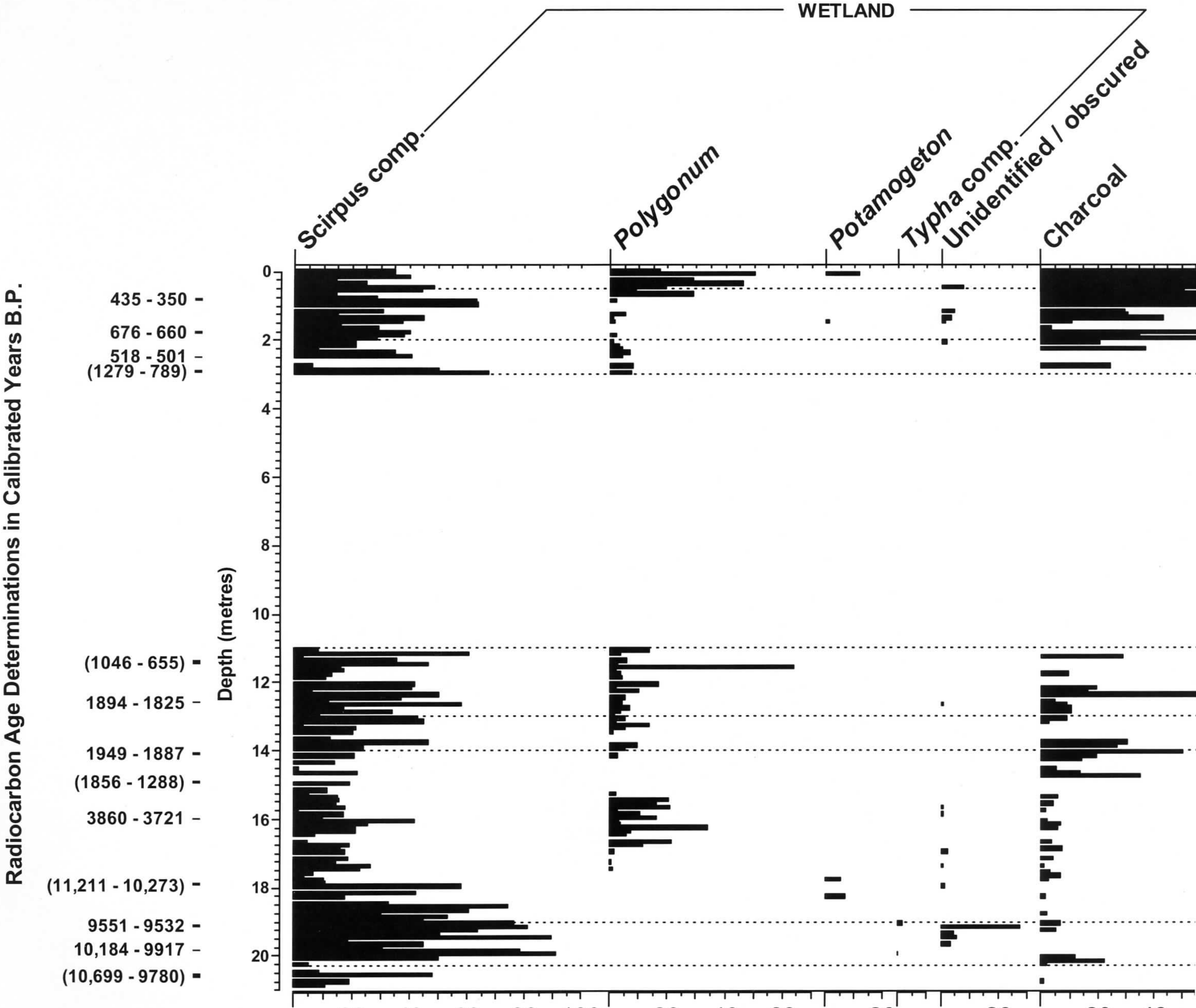
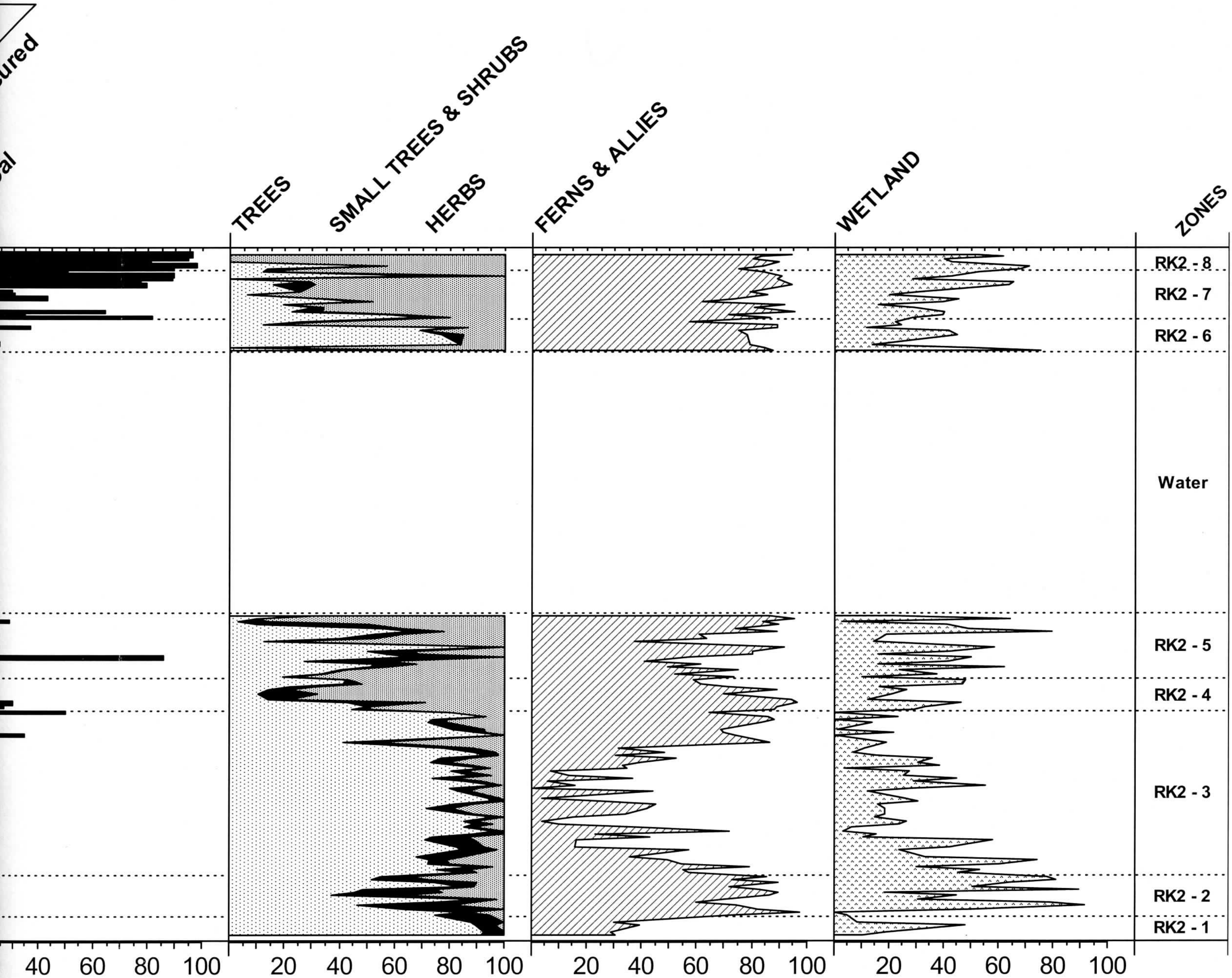


Figure 1. (continued)


ured
al
TREES
SMALL TREES & SHRUBS
HERBS
FERNS & ALLIES
WETLAND
ZONES
RK2 - 8
RK2 - 7
RK2 - 6
Water
RK2 - 5
RK2 - 4
RK2 - 3
RK2 - 2
RK2 - 1
40 60 80 100
20 40 60 80 100
20 40 60 80 100
20 40 60 80 100

bly also led to land-slipping, that destroyed terraced gardens on the caldera slopes. The extra precipitation doubtless made other, drier parts of the island more suitable for agriculture, and probably led to migration out of the crater to other, now more suitable, parts of the island.

<u>Water Gap, 11 m. – 3 m., c.1000 BP or later</u>
The interpretation of the water gap is unclear. It could be the result of a climatic change at some time in the last millennium, which might correlate with the ending of the hiatus in deposition at Rano Raraku (Mann et al., 2008; Saez et al., 2009). Alternatively, it could be a more local phenomenon. On the seaward side of the caldera there are freshwater springs in the cliff, believed to be leakage from the caldera lake. It is possible that there were originally more of these, and that they are being progressively blocked by the sedimentation in the lake (Horrocks et al., in prep). This might cause a progressive rise in the water table inside the caldera. Both these explanations could be operating together.

<u>Zone RK2-6, 3 m. – 2 m., c.1000 to 600 BP</u>
The forest within the crater partially recovered during this phase, possibly because of migration out of the crater. Agriculture continued outside the crater, as shown by the charcoal values indicating burning. It is also possible that human populations varied during this period as people migrated to and away from the area around Rano Kau.

<u>Zone RK2-7, 2 m. – 0.5 m., c.600 to 150 BP</u>
Age determinations in years BP are measured from AD 1950, so this phase runs from c. AD 1350 to c. AD 1800. This is the major phase of final deforestation of the island. The palm forest disappears, along with the *Sophora* and the *Triumfetta*. *Brousonettia* (paper mulberry) continues to thrive in the crater, where it survives to this day. High levels of burning led to grassland prevailing over the lower parts of the island where they were not in cultivation.

<u>Zone RK2-8, 0.5 m – 0.0 m., c.150 BP to present.</u>
The final extinction of the *Paschalococos* palm and the *Sophora* has occurred, and *Triumfetta* is reduced to the few trees remaining in the crater today. Burning continues, with grasses totally dominating the vegetation especially since the introduction of sheep, horses, goats and cattle. In the marginal swamp, the medicinal *Polygonum* thrives.

DISCUSSION

Undoubtedly the most interesting feature of the diagram is the interpretation that human disturbance began around 1900 BP (c. AD100), and continued thereafter, perhaps varying in intensity but never ceasing. This is so contrary to most archaeological reconstructions, especially some more recently proposed, that it needs special examination. A decline of forest, accompanied by charcoal, could result from several causes. Spontaneous combustion, especially in swamps, is not unknown. Fires can also result from lightning, and are known to occur in drier climates. Volcanic eruptions frequently cause fires. And of course people light fires, especially for agricultural purposes. In addition, charcoal can be carried long distances (Butler, 2008).

In relation to these possibilities, the following are relevant points:

- Lightning is rare on Pacific Islands (Doswell, 2002) and when it does occur it is nearly always accompanied by heavy rain storms, which discourages fire.
- There is no obvious volcanic ash around the 1900 BP date, but there has been volcanic activity on the island in the last 2000 years at Maunga Hiva-hiva (González-Ferrán et al, 2004).
- The charcoal levels in the core never return for long to background levels after the 1900 BP date, suggesting continuous disturbance.
- The date suggested for human arrival on Rapa Nui, using linguistic evidence was c. AD100 (Flenley and Bahn, 2003)

In the circumstances, the evidence remains equivocal, but cannot be dismissed. We must await further research, which is now under way.

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